Chemical Storage in Schools and Impact on Indoor Air Quality

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The Department of Public Health, Bureau of Environmental Health Assessment (BEHA), Emergency Response/Indoor Air Quality Program (ER/IAQ) conducts indoor air investigations in public buildings or building that the public may enter. The BEHA works with local boards of health, school departments and the general public to address and remediate indoor air problems in public schools. During the investigation of an indoor air quality complaint in schools, building design, maintenance and school activities can all play roles in adversely affecting air quality. Over the course of hundreds of indoor air inspections done over the past several years, improper storage of chemicals in school chemistry departments has served as a source of indoor environmental pollutants as well as potential safety hazards. The following are examples of storage conditions of science laboratory chemicals. Each example lists poor storage conditions that could either be safety or chemical off-gassing hazards that can affect indoor air quality. These examples have been edited from original reports to present circumstances observed during these inspections.

Example 1-A High School Chemical Storeroom

Condition 1. A non-flame-proof, gray metal cabinet exists in this room, which is used for chemical storage. Upon opening the cabinet doors, a strong, irritating chemical odor was released into the storage area.

Explanation of Hazard 1: The odor of stored chemicals indicates that containers are not sealed properly, leading to off gassing into the cabinet. With this condition it is likely that vapors were slowly seeping from the cabinet over time, or were immediately released whenever the cabinet doors were opened. Chemical containers must be properly sealed to prevent evaporation.

Example 2-A High School Chemical Storage Room

Condition 1: In this school the condition of potassium metal storage was noted.
In an elevated wooden cabinet, a sealed glass bottle contains a liquid in which a cube of potassium metal was stored. The stopper was made of cork, which allowed the storage fluid to evaporate, exposing the potassium metal to air. In addition, other water reactive metals were stored on the top shelf without any barriers to prevent bottles from falling out upon opening of the cabinet door

Explanation of Hazard 1: Alkaline metals (e.g., sodium, potassium) are water reactive (NFPA, 1991) and are a fire hazard. Both water and moist air can create an explosion hazard if mixed with alkaline metals. These metals are typically stored submerged in a fluid (usually kerosene) to prevent contact with air. The condition of this container allowed a slow evaporation of kerosene. Kerosene also contains a number of volatile organic compounds that can be irritating to the respiratory system. Breakage of alkaline metal containers has lead to chemical lab fires. Care should be taken to store alkaline metal containers in a manner to prevent breakage and exposure to moisture.

Condition 2: Several free standing, open-ended glass barometers containing elemental mercury were found in this science lab. The tops of these devices were not sealed, which allows the elemental mercury in the pipettes to be exposed to ambient air.

Explanation of Hazard 2: Elemental mercury must be stored in a manner that prevents its evaporation. Mercury vapor is a hazardous material that can cause serious health effects. The Agency for Toxic Substances and Disease Registry (ATSDR) and the US Environmental Protection Agency (EPA) recommend that elemental mercury be properly stored and cleaned up if spilled (EPA/ATSDR, 1997). These barometer pipettes should be sealed, drained of mercury and sealed, or discarded as hazardous waste. The present storage of these glass barometers can result in these devices being upended and broken, resulting in an elemental mercury spill.

Condition 3: A wooden cabinet with wooden shelves and metal shelf supports served as the acid storage area. These shelves were packed with numerous acids in glass bottles, including sulfuric acid and hydrogen fluoride. Several of these bottles were sealed with rubber corks, which can degrade when exposed to acid.

Explanation of Hazard 3: Improperly sealed acid containers can off-gas resulting in corrosion of the metal shelf supports. All screws and supports for this cabinet appeared to be steel, which can readily corrode when exposed to acids and undermine the integrity of the shelf supports. With continued corrosion, an accidental bump to the shelf could cause these shelves to fail, resulting in the breakage of the acid glass containers and subsequent opportunity for release into the chemical storage area. Acids should be stored in an acid resistant cabinet. (Hedberg, D.D., 1987)

Example 3-A High School Chemical Storage Room

Condition 1:. The flammable storage cabinet contained petroleum ether, xylene, benzene, carbon tetrachloride, and numerous other materials, which could not be examined due to the overloading of chemical bottles on shelves. Many materials in this cabinet are extremely flammable and appeared not to be in use. Of note is a rusted paper towel dispenser opposite from the flammable storage cabinet, which may indicate corrosion from chemical vapors. The flammable storage cabinet was also vented.

Explanation of Hazard 1: Signs of corrosion on metal, such as the paper towel dispenser, can indicate chemical off-gassing from this cabinet. The National Fire Prevention Association (NFPA) does not require venting in flammable storage cabinets, however, if venting is done, it must be vented directly outdoors and in a manner not to compromise the specific performance of the cabinet (NFPA, 1996). If air backflow from outdoors into the cabinet through the venting occurs, off-gassing chemicals can be forced from the flammable storage cabinet into the storeroom. Proper design of exhaust vents should prevent air backflow into this cabinet.

Condition 2: A shelf containing household products, particularly ammonium hydroxide cleaner and drain cleaner was observed.

Explanation of Hazard 2: If the drain cleaner contains an acidic material, these products can interact and should not be stored together. The storage of reactive materials (e.g., acids and bases) side-by-side can lead to chemical reactions if containers are improperly sealed or accidentally mixed. Separating reactive materials is good chemical storage practice.

Example 4-A Combination High School/Middle School

Condition 1: Several Bunsen burner pads with a crumbling white material were stored on shelves.

Explanation of Hazard 1: Asbestos pipe insulation, floor tiles, mastics and other building materials have long been recognized as health hazards and are required to be remediated under federal law. Other, non-structural sources of asbestos, such as Bunsen burner screens, may contain asbestos. These materials must be removed in a manner consistent with asbestos mitigation regulations (DLWD, 1998).

Condition 2: The chemical storeroom appeared to have local exhaust ventilation, which was off during this inspection.

Explanation of Hazard: Mechanical exhaust ventilation systems in chemical storerooms are designed to draw and directly exhaust chemical vapors to the outdoors. Without a functioning local exhaust ventilation, off-gassing chemicals can accumulate within the storeroom and be drawn into adjacent classrooms by other ventilation systems.

In all of these examples, chemical storage in the science departments of these schools presented potentially serious fire and chemical off-gassing dangers. The effect on indoor air quality of these buildings from off-gassing chemicals is clear. In buildings with non-existent, poorly designed or malfunctioning ventilation systems, off-gassing chemicals in storage areas can be drawn into occupied areas. In addition, inadequate storage conditions and mechanical exhaust ventilation can lead to build up of gases and vapors that can serve as a source of odors and respiratory irritants.

If you plan on doing an inspection of a school laboratory storage area, the following conditions are signs of poor storage and handling procedures in addition to the above-listed examples.

1. All chemicals are stored in alphabetical order- This can lead to incompatible materials being stored together creating a chemical interaction hazard. A general rule of thumb is to store chemicals of the same safety hazard together, with incompatible materials separated.

2. Storage of flammable materials outside of the flammable storage cabinet- Boxes labeled with a Department of Transportation red diamond placard confirms that the material is flammable (NAERG96, 1996) and that the contents should be stored in a flammable storage cabinet.

3. The labeling of chemical storage bottles with a chemical formula (e.g., NaOH)- In a spill emergency, an emergency responder without a chemistry education may not be able to identify the formula-labeled container contents (in this example,sodium hydroxide). All containers should be labeled with the chemical name.

4. The storage of oxidizers on wooden shelves- A spill of an oxidizer on wood can result in fire.

5. Unsecured gas cylinders- Gases stored in these containers are under pressure. If the valves on the cylinder are damaged, these cylinders can then become unguided rockets with the uncontrolled release of gas. In addition, gases such as chlorine, hydrogen sulfide, hydrogen and oxygen have been found in schools during these inspections. All of these materials pose either a health or safety risk is released through an accident.

6. Non-functional chemical storeroom mechanical ventilation- If a ventilation system is off, off-gassing chemicals can build up. If the system is backdrafting (air flowing from the outdoors into a building by the exhaust vent) off-gassing chemical vapors can be transported into adjacent hallways and classrooms.

7. Any container labeled ethyl ether or picric acid that has dry powder in the container- Both of these materials are shock sensitive, which can result in an explosion if the container is moved. If these containers are found, secure the storeroom and contact the hazardous materials specialist of your local fire department immediately.

8. If an elementary or middle school was formerly a high school- Examine the former science department area for stored chemicals that were left behind after the move to a new facility. It has been our experience that unwanted chemicals stored in middle schools that are former high schools are frequently found. Aging chemicals can become unstable and present safety hazards. In all of these examples, inadequate handling and storage procedures can results in laboratory chemicals being point sources of indoor air pollutants. In order to avoid the chemistry laboratory from having an adverse effect on indoor quality, chemical safety training, operation of exhaust ventilation, proper storage of chemicals and an increased awareness of the potential must be impressed upon all teachers and staff in the school environment.

Chemical storage is but one aspect of indoor air quality that is investigated during inspections of schools. If you have any questions or require technical assistance concerning indoor air quality in public buildings, please contact the Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, Emergency Response/Indoor Air Quality Program at (617) 624-5757.

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